Bulletin No. 24. *February*, 1933.

UNIVERSITY OF ALBERTA
COLLEGE OF AGRICULTURE

Insect Pests of Grain in Alberta

BY

E. H. STRICKLAND
PROFESSOR OF ENTOMOLOGY

Distributed by
DEPARTMENT OF EXTENSION, UNIVERSITY OF ALBERTA
Edmonton, Alberta

Bulletin No. 24. *February*, 1933.

UNIVERSITY OF ALBERTA
COLLEGE OF AGRICULTURE

Insect Pests of Grain in Alberta

BY

E. H. STRICKLAND
PROFESSOR OF ENTOMOLOGY

Distributed by
DEPARTMENT OF EXTENSION, UNIVERSITY OF ALBERTA
Edmonton, Alberta, Canada

COMMITTEE ON AGRICULTURAL EXTENSION AND PUBLICATIONS

R. C. WALLACE, M.A., Ph.D., D.Sc., LL.D., F.G.S., F.R.S.C., President of the University, Chairman.

E. A. HOWES, B.S.A., D.Sc., Dean of the Faculty of Agriculture, Vice-Chairman.

F. A. WYATT, B.S.A., M.S., Ph.D., Professor of Soils.

J. MACGREGOR SMITH, B.S.A., Professor of Agricultural Engineering.

J. P. SACKVILLE, B.S.A., M.S., Professor of Animal Husbandry.

C. P. MARKER, LL.D., Professor of Dairying.

E. H. STRICKLAND, M.Sc., Professor of Entomology.

P. R. TALBOT, V.S., M.D.V., Provincial Veterinarian.

O. S. AAMODT, B.S., M.S., Ph.D., Professor of Field Crops.

E. A. CORBETT, M.A., Director of the Department of Extension.

DONALD CAMERON, B.Sc., Agricultural Secretary, Department of Extension.

CONTENTS

INSECT PESTS OF GRAIN IN ALBERTA

BY

E. H. STRICKLAND
Professor of Entomology.

Farmers in Alberta are fortunate in that they have to contend with comparatively few insect pests in grain fields. Several of those that do occur in this province are liable, however, to be extremely destructive from time to time.

Certain of these, such as wireworms and wheatstem sawflies cause appreciable losses every year in those districts in which they are well established; others, such as grasshoppers and cutworms, normally are present in too small numbers to cause much concern. Outbreaks of the latter, however, are liable to occur with such intensity over a period of years that the losses they occasion are very great.

With the knowledge we have at the present time we are unable to gain complete control of any of these pests. The habits of all of them are, however, sufficiently well understood for all farmers to be able to reduce the damage that they would otherwise do by following the advice that is given in the following pages. This advice is, to a large extent, the outcome of our own experience, though much of it has been obtained from publications of other workers, particularly those of members of the three Dominion Entomological Laboratories situated in the prairie provinces.

In this bulletin the discussion of each pest must, of necessity, be brief. For this reason, references to more complete information are given at the end of each discussion. The majority of publications can be obtained, free of charge, by writing to the institution which issued them. The publications of the Dominion Entomological Branch can be obtained direct from Ottawa, from the Entomological Laboratory at Lethbridge, or from this University. References to publications that are not readily obtainable are not given.

RECOGNITION OF INSECT PESTS.

In order that a farmer may select the most suitable method for avoiding or for reducing insect damage, it is necessary for him to identify the insect that is causing it. In many instances he is more liable to notice the damage to his crops than he is to observe the insect that is responsible for it.

We have, therefore, prepared the following table to assist in the identification of the culprit from the appearance of the damaged plants themselves.

1. Plants fail to appear above ground.

Dig up, and examine, a number of grains.

a. Grains complete, but have failed to germinate. Not insect damage.

b. Contents of grain are eaten out. *Large Wireworms* (page 36).

c. Embryos have disappeared. *Small Wireworms* (page 36).

2. Plants above ground, but not yet headed out.

a. Dead plants projecting from soil, blades tightly rolled up and dry. *Wireworms* (page 36).

b. Plants, for greater part, cut off at ground level and lying on surface of the soil. *Cutworms* (page 19).

c. Central shoot of plants dead, older blades healthy. *Wireworms* (page 36), or *Sheath Miners* (page 52).

d. Tips of blades yellow, or turning brown, with reddish spots at about half their length from the base. *False Chinch Bugs* (page 54).

e. Blades irregularly notched along their edges or entirely eaten. Probably *Grasshoppers* (page 11), sometimes *Cutworms* (page 21).

3. Heads formed but grain not ripening.

a. Wheat straws bent over near base and head again turning upwards so that each straw is an N shape. This is not Hessian Fly or any other insect damage. Probably due to very rapid growth followed by heavy winds.

b. Scattered ears of wheat throughout field have turned white, remainder of plant apparently healthy.

Pull out head, with straw, from leaf sheath. If the straw breaks off straight across at the point where it turns white this is not insect damage. The cause is not known. If the straw is irregularly chewed at the base it is *Stem Maggot* (page 52).

c. Heads covered with greenish or orange coloured plant-lice. Most common on oats. *Grain Aphis* (page 55).

d. Many flowers at base of head are "blind," i.e., no grain formed and turn white permaturely. Most common on oats. "Blind" oats may be produced by a variety of different causes, other than insects. When confined to bases of heads often due to *Thrips* (page 58).

4. **Heads ripening or fully ripe.**
   a. Wheat stems cut from plants close to ground. *Wheatstem Sawfly* (page 47).
   b. Wheat heads cut from plants and fall to ground. *Grasshoppers* (page 11).
   c. Oats. Individual oats cut from heads and scattered on ground. *Grasshoppers* (page 11).
   d. Rye. Exposed half of grains eaten. *Grasshoppers* (page 11).
   e. Small lace-like cocoons containing a brown-striped caterpillar or small white chrysalis fastened to heads of wheat. *Diamond Backed Moth* (page 58).

TABLE FOR THE RECOGNITION OF INSECTS MOST COMMONLY FOUND IN GRAIN FIELDS IN ALBERTA

1. **More or less worm-like insects** that may or may not have legs. Found upon or below the surface of the soil.
   a. *Cutworms*, i.e., smooth skinned caterpillars, up to about 1½" long. Usually found below the soil surface. See *Cutworms* (page 19) for a table for the identification of common species.
   b. *Dull brown* cutworm-like insects with wrinkled skins and apparently no heads or legs. Not very active.
      (1) Never more than ½" long. Body covered with fleshy spurs somewhat resembling rose thorns. Sometimes very numerous in the spring. *March flies* (page 56).
      (2) Up to 1¼" long. No fleshy spurs on body. *Leather jackets* (page 56).
   c. *Orange* coloured shining grubs with very tough skins. Up to 1" in length. Always found below ground.
      (1) Not very active when disturbed. Usually rather flattened and with two blunt claws at the hind end of body. *Wireworms* (page 36).
      (2) Extremely active when disturbed. Body cylindrical and always pointed at hind end. *False wireworms* (page 46).
   d. *White "worms"* that are very slender, with no legs; up to 1" long; extremely active when disturbed. These are the larvae of a fly. They feed on other insects. Beneficial. *Thereoid larvae.*
   e. *White grubs* with brown heads and well developed legs. Do not curl up when disturbed; run rapidly. Usually about ¼" long. These feed mainly on very young wireworms, cutworms and grasshopper eggs. Beneficial. *Ground beetle larvae.*
   f. *Black grubs*, up to 1" long. Well developed legs, run rapidly. Feed on cutworms and wireworms. Very beneficial. *Cutworm lions* (page 23).
   g. *Greyish white grubs*, about ¼" long by the middle of June, body always bent in a ⊃ shape so that its hind end lies under the head. Look somewhat like small cutworms. Quite harmless, often numerous in fields which have been manured. *Dung-beetle larvae.*

2. **Moths.**
   a. Brown, black or grey moths, about 1" long, that are very common in houses throughout the summer. Most of these are *Army cutworm moths* (page 33), *Glassy cutworm moths* (page

36), or the moths of other cutworms that are not very injurious to grain. The greenish moths of the *Pale western cutworm* (page 28), and the reddish or yellow moths of the *Red-backed cutworm* (page 31) do not often enter houses. They may be very abundant in the fields, but do not attract much attention since they fly chiefly after dark.

b. Small light grey moths, about ¾" long, often fly in clouds around flowering weeds and around lights at night. *Beet webworm* (page 57).

3. Beetles.

a. Small black or brown beetles that run very quickly, and hide under stones, etc. Nearly all feed on other insects and are beneficial. *Ground beetles.*

b. Small black beetles, about ½" long. Walk rather slowly. More slender than ground beetles, and with a distinct furrow across the middle of their backs. If placed up-side-down on a *smooth* surface they soon jump into the air with an audible "click." No other beetles do this. *Wireworm beetles* (page 36).

c. Large black beetles, sometimes spotted with red or green, about 1" long. Long legs, run *very* quickly. *Fiery hunters* (page 23).

d. Large black beetles, up to 1" long. Walk very clumsily, and stand on their heads if mildly alarmed. Often seen in gopher holes. *False wireworm beetles* (page 45).

4. Grasshoppers and Crickets.

There are about 70 different kinds of grasshoppers in Alberta. Of these not more than three are liable to be very injurious in grain fields. See *Grasshoppers* (page 11) for tables for the identification of immature hoppers, grasshoppers and crickets.

5. Flying insects other than moths, beetles or grasshoppers.

a. Black and yellow wasp-like insects, about ¼" long. Usually rest head downwards on wheat stems. Seen only in May and June. *Wheatstem Sawflies* (page 47).

b. Slender black insects with black wings, about 1" long. Very active; run on ground or make short flights. Capture, and eventually destroy, half to full-grown cutworms. Beneficial. *Solitary wasps* (page 23).

6. Eggs, pupae or cocoons turned up with the plough.

a. Covered with, or entirely composed of, earth.

(1) Hard, less than an inch long, somewhat resemble gopher droppings. When broken open seen to contain yellow eggs. *Grasshopper eggs* (page 11).

(2) Hard, about 1½" long, roughly oval, composed entirely of earth. Usually found with one end open and empty. *Cutworm pupation cells* (page 19).

(3) Soft, about 1" long, narrow, elongate, somewhat resemble pieces of decaying sticks. When pulled apart seen to be composed of silk. May contain small caterpillar or pupa. *Beet webworm cocoons* (page 57).

b. Reddish brown, hard shelled, chrysalis, less than an inch long. Hind end ringed and movable. *Cutworm pupa* (page 19).

c. White, delicate skinned pupa, with very soft wings and legs all pointing backwards and lying on the underside of the body. Beetle pupa probably of *Ground Beetle, Wireworm or False Wireworm*

d. Hard-shelled, dark brown oval structure with a perfectly smooth surface. Usually open at one end and empty.

(1) About ½" long. Similar objects abundant in dead animals. *Pupa of a Fly.* Probably a cutworm parasite.

(2) About 1" long, appears to be composed of many very thin sheets of a matter of that has metallic reflections. *Cocoon of Solitary Wasp* (page 23)

RELATION BETWEEN THE LIFE-HISTORY OF INSECTS AND CONTROL MEASURES.

Nearly all insects change in their appearance, and often in their feeding habits to a greater or less extent, between the time that they hatch in a wingless condition from their eggs and that on which they are fully developed flying insects.

A recently hatched "hopper" is, however, sufficiently similar in appearance to a mature flying grasshopper for anyone to recognize it as being the same insect. Whenever the change in appearance is no greater than this the insect can be *active* throughout its life and its *feeding habits* do not change from the time it hatches till it dies. For this reason we can *usually employ the same control measures for these insects throughout their lives.*

A caterpillar or cutworm, on the other hand, is so totally different from the moth into which it will develop that no one, who did not already know it, could tell that it really is a young moth.

So great is the difference in structure between the caterpillar and the moth that the insect cannot change from the one to the other without becoming *inactive*, as a pupa, while the change is taking place. Not only does the structure change completely, but so also, do the *feeding habits.* The cutworm eats solid food, such as leaves, while the moth can suck up fluids only, and feeds on nectar from flowers.

We cannot, therefore, employ the same control methods throughout the life of the insect. In certain cases it is much easier to control such insects in a stage in which they may be doing us no damage whatever than it is in the stage in which they are serious pests.

CONTROL MEASURES THAT CAN BE EMPLOYED BY GRAIN PRODUCERS.

Spraying and Dusting.

Generally speaking, grain producers will rarely find it to be practical to employ poisoned sprays or dusts for the control of insect pests. The areas devoted to their crops are too large, and the intrinsic value of their produce is not sufficiently great to warrant the expense that this would entail.

We must, therefore, look for less expensive measures, even though they may not quite as effective.

Use of Poisons.

The only practical method whereby insects in grain crops can be poisoned is by employing poisoned baits. These are of great value in connection with the control of grasshoppers and of certain cutworms, but they cannot be satisfactorily employed for other insect pests.

Constant efforts have been made to find materials that can be applied to, or drilled in with, the seed in order to protect it from insects such as wireworms. None has been found that can be employed in this manner except at prohibitive costs.

Cultural Practices.

Since the majority of grain pests live, for at least a part of their lives, below ground, it is often possible to reduce their numbers or the damage that they can do, by modifying the usual cultural practices that are employed in the district. Several such modifications will be discussed in this bulletin in connection with various insect pests. When they can be employed without seriously upsetting the routine of the year or resulting in danger of soil drifting, loss of moisture, etc., they should always receive very careful attention. These modifications entail no additional expense and may greatly reduce losses from insect pests.

It should also be borne in mind that vigorous plants, as a rule, suffer less from insect damage than do those which are making a poor growth. For this reason, rapid growth should be encouraged at all times. In the case of certain insects, such as wireworms, the application of fertilizers, particularly phosphates, in order to counteract soil deficiencies in these materials may so stimulate the plants that they have a marked effect in reducing insect damage.

Rotations and Trap Crops.

The principle of rotations, as applied to insect pests, is to

avoid growing the same crop year after year in the same field, since this gives the insects that normally feed upon it an opportunity to increase in numbers.

Under existing conditions there is little scope for practising rotations on grain producing farms. In districts that are infested with the wheatstem sawfly it will, however, be seen that rotating wheat with some other non susceptible crop or with summerfallow, is practically a necessity during years of sawfly abundance. In order to be fully effective, such rotations must be practised in conjunction with trap crops to arrest the spread of the egg laying females.

GRASSHOPPERS AND CRICKETS.

As has already been pointed out, there are about 70 different kinds of grasshoppers in Alberta. The majority of these are not a menace to grain producers since they feed almost exclusively on native grasses and weeds. Several of them are, as a matter of fact, more beneficial than otherwise. They harbour important parasites of the injurious species at seasons of the year when the latter are not available for them.

There are, however, three species that are liable to be extremely destructive to grain when they are present in abnormally large numbers. Outbreaks of these grasshoppers as a rule take a number of years to develop, and they could often be checked from the start if everyone in the threatened territory noticed the gradual increase in numbers and immediately took the proper steps to reduce them.

For this reason, and also in order that money and labour will not be wasted in an attempt to reduce the numbers of the harmless species, it is very important that everyone is able to recognize the injurious grasshoppers in all stages of their development.

TABLE FOR THE RECOGNITION OF COMMON GRASSHOPPERS AND CRICKETS IN ALBERTA

1 Small wingless hoppers, only partly grown. (All injurious grasshoppers are in this stage of development only late in May and throughout June.)

a. Mainly black, but with strongly contrasting white marks on body and legs. Usually found in sod around grain fields or in small pastures. *Roadside Grasshopper* (page 13)

b. Bright yellow-and-black, with fine black lines on developing wing cases. Most abundant in deserted fields, or in stubble with a dense growth of weeds. *Lesser Migratory Grasshopper* (page 16)

c. Bright green. Most abundant in fall rye or weedy areas. *Two-striped Grasshopper* (page 16)

d. Light grey, more slender than usual. Often found in mid at a distance from cultivated land. These are *harmless* to grain.

2. Full-grown grasshoppers and crickets.

a. Coloured hind wings, red and black, or yellow and black. All of these are practically *harmless* to grain.

b. Transparent hind wings.

(1) 1 1/2" long. Mottled brown or yellow, with large dark marks on front wings, and two rather faint yellowish stripes forming a long V on body. Eyes round. *Roadside Grasshopper* (page 15)

(2) 1 1/4" long. Nearly uniform brown without very definite marks on front wings. Eyes about twice as long as wide. *Lesser Migratory Grasshopper* (page 16)

(3) 1 1/2 2" long. Dull greenish yellow. Front wings about the same colour as body with the exception of two conspicuous straw yellow stripes forming a long V along the top of the body. Eyes about twice as long as wide. *Two-striped Grasshopper* (page 16)

c. Wingless. About 1", 2" long, much slender than an ordinary grasshopper. Female with a sword like ovipositor that is nearly as long as the rest of the body. Most abundant in the foot hills. *Mormon Cricket* (page 18)

d. Black crickets, about 1" long, incapable of flight but with short wings. *Field Cricket* (page 18)

Habits of all Injurious Grasshoppers.

All injurious grasshoppers lay their eggs in the soil. The females dig holes in the ground and fill them with about 25, or in some cases with about 50 eggs. These are surrounded with a gummy substance that hardens and sticks the eggs together. When dug up these "egg masses" somewhat resemble gopher droppings until they are broken open to expose the elongate light yellow eggs.

Though the eggs are all laid in the fall they do not hatch till about the end of the following May.

The small wingless 'hoppers that then hatch feed continually on vegetation and gradually increase in size until early in July, when most of them are full grown and are able to fly. They then become much scattered throughout grain fields that may have been free from 'hoppers earlier in the year.

Hoppers grow by a process of moulting, they shed their "skins" periodically. Whenever hoppers are numerous these cast empty skins will be found in large numbers. They must not be confused with dead 'hoppers.

The flying grasshoppers continue to feed. They begin to lay their eggs about the end of July and continue to do so until they are killed by frosts in the fall.

Causes of Grasshopper Outbreaks.

A variety of climatic conditions produce grasshopper outbreaks. Generally speaking, a succession of dry hot years with open falls results in an increase in the number of grasshoppers. Timely rains, with cold, overcast weather in the latter part of May, may kill a great many of the young hoppers, but a wet season cannot be relied upon to terminate an outbreak

Termination of Outbreaks.

One of the most important factors that terminate outbreaks is the gradual increase of their natural enemies other insects that are parasitic upon them. In the early stages of an outbreak the proportion of parasites to grasshoppers is very small It usually takes them several years in which to re-establish their numbers at the expense of the grasshoppers. If, during these years, we can destroy a large number of the grasshoppers with baits or by any other means, we hold their numbers more closely to the proper proportion with the parasites and hasten the year in which the latter will again be able to keep them under control.

Control Measures.

1 Cultural.

No eggs are ever laid in well worked summerfallow land. Such fields will be free from 'hoppers in the early spring, but they may later be infested by migrations from elsewhere.

Since many eggs (Lesser Migratory and Two-striped Grasshoppers) are laid in weedy stubble, this should either be lightly cultivated in the early fall to expose the eggs, or deeply ploughed later in the fall or in the spring. Packing after spring ploughing is advisable.

2. Bait.

The most economical bait that we have found to be effective in Alberta is:

Bran and Sawdust (half and half)	100 lbs.
White Arsenic (or Paris Green)	5 lbs.
Salt	6 lbs.
Water	10-12 gals.

Arsenic is now available in a liquid form. When this is employed, use one quart to 100 lbs. of bait.

When no sawdust is available 100 lbs. of bran can be used.

At times it has been found that somewhat better results can be obtained by reducing the salt to 3 lbs. and adding a

gallon of molasses. This increases costs. It might be advisable to try out both formulae at the beginning of the season and, if good results are obtained with the salt, not to use the more expensive formula again. Molasses, generally, is desirable where the soil tends to be alkaline.

Mixing poisoned bait During serious outbreaks bait is usually supplied free of cost to farmers by the Department of Agriculture or by the Municipal Councils. This bait is prepared in mixing centres and can be relied upon to be satisfactory.

Where no mixing centre has been established bait can be mixed by hand. Spread the bran and sawdust on the floor of a barn or other building from which stock can be excluded. Scatter the arsenic over this and mix in thoroughly by turning over with a hoe or shovel. Be careful not to allow the arsenic to fly in the air. It may cause skin burning, and is dangerous if inhaled. Dissolve the salt (and molasses) in about half of the water you think you will require, and stir it into the bait. When liquid arsenic is employed this is added to the water in which the salt has been dissolved. Continue to add water, a little at a time, till the bait is as wet as you can make it without being able to squeeze water out of a handful. The bait is now ready for immediate use, but it can be bagged and stored for two or three days if desired.

Application of bait Never scatter bait anywhere where grasshoppers are not numerous, as soon as it is dry it loses most of its attraction for them.

Never apply bait on a cold, windy or rainy day.

Broadcast bait between the hours of 7 and 10 a.m. At this time grasshoppers are doing most of their feeding, and the bait remains moist for the longest time.

Throw the bait as far from you as you can. One poisoned flake will kill several small grasshoppers. The more scattered these flakes are the better will be the killing.

Ten pounds of prepared bait is ample for an acre. All bait used in excess of this is wasted.

Danger to stock Properly scattered, bait is absolutely harmless to stock. When stock are killed it is *always* due to improper handling of bait. Never leave bait in *bulk* where stock can get at it. *Bury* any bait that is not used (burning will not destroy arsenic). Don't use bags that have contained bait for feed, and do not leave them where stock can lick

them. If baiting pastures, see that the stock are well supplied with salt, and be sure you scatter the bait thoroughly

3. Hopper Dozers.

These mechanical grasshopper catchers are so inferior to bait that they are of no practical value under Albertan conditions.

ROADSIDE GRASSHOPPER (Camnula pellucida)

FIG. 1—Roadside Grasshopper. A Egg masses, one broken open to show eggs, B Young hopper, soon after hatching (much enlarged) C. Full-grown grasshopper laying eggs. All except B are natural size (Original)

Distribution Entire province. Most abundant in southern half and in Peace River District. Usually found in largest numbers where soil is rather heavy

Life history The eggs are nearly always laid in *unbroken sod*. The females collect into well-defined breeding areas, in which practically all of them lay their eggs. During outbreaks eggs may be very abundant in the *sod* around grain fields. Even here they will be found only in well defined breeding areas, possibly of only a few rods in length

When the small black and white hoppers hatch they may at once spread into the edges of the grain field by day, but for about the first two weeks of their life they return at night to the sod where they hatched A little later they spread throughout the entire fields. When half grown they are almost completely black, and are more "chunky" in build than are most grasshoppers.

Special Control Measures.

Burning over sod. Since, for about two weeks at the end of May or early in June, roadside hoppers collect in the sod around fields every night, nearly all of them can be killed by

scattering a little straw here and burning it off after dark. The only precaution to take is to be sure that all of the hoppers have hatched. Fire will not destroy the buried eggs. Nearly all hoppers will have hatched within three days of the time that the first were seen.

Bait. The best results will be obtained by using bait *early in the season* while the hoppers are still crowded together in the breeding areas. In midsummer, when they are already scattered, baiting is of far less value. In late summer, however, when the grasshoppers are collecting into their breeding areas again, these areas can be baited with excellent results.

LESSER MIGRATORY GRASSHOPPER (Melanoplus mexicanus)
TWO-STRIPED GRASSHOPPER (Melanoplus bivittatus).

FIG 2—A, Lesser Migratory Grasshopper; B, Two-striped Grasshopper. Both natural size. (Original.)

The habits of these two grasshoppers are sufficiently similar that, for all practical purposes, the control measures for them are the same.

Distribution. Entire province, but most abundant in districts in which the soil tends to be light.

Life-history. Eggs usually laid in deserted fields and in weedy crops. Since these eggs are scattered throughout such fields, the control of these species is far more difficult than is that of the Roadside grasshopper.

Special Control Measures.

Burning weeds. When a field in which there is a dense growth of weeds, such as Russian thistle or mustard, is found to be heavily infested with hoppers, it should be burned over shortly after all of the hoppers have hatched. This can often be accomplished with the aid of harrows, etc., when a good burn cannot be otherwise obtained. The hotter the day, as a general rule, the more complete will be the burn. For these hoppers there is no advantage in burning at night.

In this connection it should be remembered that it is in such fields that the increase in the number of grasshoppers takes place. They are the source of infestation of grain fields later in the season, and it is far more difficult to kill grasshoppers in grain fields with bait than it is to destroy them with fire among weeds.

Summerfallowing Land that is being summerfallowed, and which is found to be heavily infested with hoppers, should be ploughed from the outside towards the centre. This crowds the hoppers together on to the unploughed portion, which should be treated with bait and left for two days before ploughing is completed. When this is not done all of the hoppers that were in the field will be driven into neighbouring grain.

Bait Bait can be broadcast in uncultivated fields that cannot be burned over in early summer. This will destroy a large percentage of the hoppers.

When flying grasshoppers have entered and scattered throughout a grain field, bait should be broadcast in strips, about two rods apart, throughout the field. Since flying grasshoppers are very active, most of them will find and feed on the bait before it has dried out. This reduces the cost and labour of baiting by about half.

References to Literature on Grasshoppers.

Criddle, N., "Grasshopper control in Canada East of the Rocky Mountains." Entomological Branch Ottawa D. of A. Entom., Bull. 31, 1931.

Strickland E. H., "Control of Grasshoppers in Alberta," 1923, and "Recommendations for grasshopper control in Alberta, 1932." Department of Agriculture, Edmonton.

MORMON CRICKET (Anabrus simplex)

FIG. 3—A Female Mormon Cricket (The male has no ovipositor, and is smaller), B. Female Field Cricket. Both natural size (Original.)

Distribution. This large wingless insect does not often attract attention in Alberta, though it is liable to occur in destructive numbers in the S.W. portion of our province in seasons that have been favourable to its increase.

Life-history. The eggs, unlike those of grasshoppers, are laid singly in the soil. Early in the summer the young crickets eat plants completely. Later, when the heads are formed, they may climb up to the heads and eat out the developing grain. They do this most freely in the evening.

Control. In parts of Montana, where these insects are liable to be more numerous than we have ever known them to be in Alberta, they sometimes move across country in dense armies. Under these conditions, dusting with sodium arsenite has proved to be an excellent control measure. Here we have not experienced such migrations, but have had good success with grasshopper bait in destroying those that are feeding on grain.

FIELD CRICKET (Gryllus assimilis).

Distribution. Throughout the province.

Life-history. The eggs are laid in the soil singly. They do not hatch till about the beginning of July, and since the young crickets are unable to climb plants, they do no damage to grain. They are mature at about harvest-time. During the hottest part of the day they inhabit cracks in the soil and come out to feed only at night or on cloudy days. Unfortunately they are very fond of eating binder-twine, and, if sheaves are left lying for some time in fields in which the crickets are numerous, many of the bands may be cut by them.

Control. Twine that has been treated by the manufacturers to protect it from crickets or field mice will not be damaged

Untreated twine can be protected by soaking for half an hour in a solution of 1 lb. of Bluestone in 6 gals. of water. Thoroughly dry and pound the balls with a stick when dry to loosen them up and to avoid knotter trouble.

In a field in which crickets are seen to be numerous, stook as soon after cutting as possible.

CUTWORMS.

There are over 200 different kinds of cutworms in Alberta. Only about 50 of them ever feed on grain. Fortunately, the great majority of these occur, every year, in such small numbers that the damage any of them do is negligible.

A few species, however, increase in numbers very rapidly when climatic conditions are favourable to them, and during these years of cutworm "outbreaks" they are liable to be extremely destructive to grain crops.

The habits of those species that have caused the greatest damage in Alberta have been carefully studied, but those of the less common ones are not, in the majority of cases, very well known.

Unfortunately, it is possible that certain climatic conditions or modifications in cultural practices may, at some future date, permit outbreaks of these less common species.

TABLE FOR THE RECOGNITION OF CUTWORMS MOST FREQUENTLY SEEN IN GRAIN FIELDS.

1. General colour *light grey*, with few body markings.
   - a. Head straw-yellow with a blackish $\wedge$ or X on the front of it. Never seen before about the middle of May when they are less than ¼" long. Full-grown and about 1½" long by middle of June. *Pale Western Cutworm* (page 33)
   - b. Head bright orange-red, with no markings on it. Body shining and semi-transparent, with a dark internal stripe along the top of it. Seen as soon as the frost is out of the ground when they may be already nearly 1½" long. *Glassy Cutworm* (page 36)
   - c. Head mottled brown. Body with a number of small black spots. Seen as soon as the frost is out of the ground, when they may be nearly 1¼" long. *Hardy Cutworm* (page 35)
2. General colour *dark green or reddish*.
   - a. With a distinct brick-red band along the entire length of the body. Sides of body may be dark green or creamy yellow. Not seen before about the middle of May, when they are less than ¾" long. Full-grown and about 1½" long by middle of June. *Red-backed Cutworm* (page 31)

b. Usually dark olive-green all over, sometimes with two rows of poorly defined creamy spots, or with a dull yellowish brown band, along the top of the body. Seen as soon as the frost is out of the ground, when they are ½" to 1" long. Full-grown and about 1½" long by the end of May. *Army Cutworms* (page 33)

Methods for ascertaining rapidly whether unrecognized cutworms are liable to be destructive to grain, and the best control measures to adopt.

Should a farmer, at any time, find that his fields are heavily infested with a cutworm that he is unable to recognize he can very quickly find out enough about its habits to decide upon the best immediate steps to take by the following procedure

1. Note their average size. If they are already nearly 1½" long there is not much cause for alarm. They are practically through feeding for the year and will disappear in a few days' time.

2. If they are smaller observe, in the field, on what they are feeding or have fed. If only on broad leaved plants, such as weeds, they are in all probability harmless to grain. If, however, they feed on grass or volunteer grain they are liable to be destructive. When there is too little variety of growth in the field for their food choice to be ascertained collect a few and place them in two sealers. To one sealer add a few leaves of weeds, such as dandelion or some alfalfa and some blades of grain. To the other add only blades of grain. By the following morning you will know whether they prefer broad leaved plants or grain, and also whether they will eat the latter when there is nothing else available.

2. If they eat grain observe, in the field, whether most of their feeding is done from *above* or from *below* ground. If they feed above ground it is probable that bait broadcast as recommended on page 24 will control them. When, however, it is seen that the plants have been attacked below the ground level it is very unlikely that bait will prove to be effective.

3. Observe whether the cutworms are above ground by day. If so, and the majority of them are crawling in the same direction, bait can be applied in furrows ploughed across their line of march (see page 25). This will greatly reduce the amount of bait that is required to control them.

A word of caution is necessary. The habits of cutworms vary considerably with temperature and with soil moisture.

On cold days or nights they feed very little and tend to stay below ground. When the soil is dry at the surface they remain below ground and feed extensively there, even though they move freely on the surface when the soil is damp.

One should therefore repeat field observations under as many climatic conditions as are possible. In the meantime, if there is any doubt as to their habits, send a few specimens to the University or to Lethbridge for determination and advice.

Habits of all Injurious Cutworms.

Egg laying habits of moths. In so far as is known all of the moths of cutworms that are liable to be injurious to grain in Alberta lay their eggs exclusively in *the soil* and never on weeds or other vegetation. This is not true for all kinds of cutworms, but it certainly applies to those that are grain feeders which have been studied in detail.

As a general rule, the moths lay their eggs only where it is easy for them to place them *beneath the surface*. The eggs are laid in August or September but those of the majority of species do not hatch till the following spring. This necessitates some protection. The moths, however, are not provided with powerful organs for digging into the soil, as are grasshoppers. They are forced, therefore, to lay their eggs in fields in which either they can get under loose clods of earth, or there is a sufficiently loose layer of earth on the surface for them to be able to *rub* small holes with the end of their soft bodies in it, in order to place their eggs below ground.

Egg laying is usually accomplished just before sundown, or after dark and, for this reason, it is not often observed.

Habits of cutworms. Cutworms which hatch from their eggs in the fall feed freely on weeds till freeze-up, when they burrow just beneath the soil surface and remain inactive till the following spring.

Those which do not hatch till the spring do not often do so till after the crop has been seeded. The newly hatched cutworms all come above ground and climb up the plants, where they feed on the upper side of the blades, or else bite irregular notches in their margins. After a few days, however, they re-enter the soil and, depending on what species of cutworm they are, they either remain continually below ground and feed on the underground parts of the plants or they come above ground to feed and retire into the soil when they have finished. As a general rule, all of them remain below ground for the greater part of the day, and are most active at night time.

Pupation. When a cutworm is about 1½" long it is full grown. It now ceases to feed, burrows down to firm earth and there makes a small cavity in the soil. In this it turns to a reddish pupa, or "chrysalis," from which, at about the end of a month, the moth escapes and works its way to the surface of the soil.

Habits of the moths. Cutworm moths feed only on nectar from flowers. They are most active at night time, and many species are strongly "attracted" to lights. These are frequently a serious nuisance in houses. They are harmless to grain except in so far as they lay the eggs from which will come the next year's crop of cutworms.

Causes of Cutworm Outbreaks.

Generally speaking, injurious cutworms increase in numbers when rainfall has been below the average in May and in June. Two dry seasons in succession are, as a rule, necessary before a serious outbreak occurs. This is due to the fact that, with ample rainfall during these months, both parasites and diseases are capable of destroying so many of the cutworms that they are kept down to small numbers. Dry seasons hamper the effectiveness of both of them.

Termination of Cutworm Outbreaks.

It is commonly believed in many quarters that rain kills cutworms directly. This is, however, not the case. Rain greatly reduces their feeding activities for as long as the soil remains moist. It also strengthens the plants, allowing many that have been only slightly damaged to recover. Rain in May and June does greatly reduce the number of cutworms that will be in the district in the *following year*, because it allows parasites and disease to destroy more of them before they develop into egg laying moths. On page 30 will be found Mr. Seaman's formula for forecasting the abundance of Pale Western Cutworms from records of wet days in May and June.

Important Enemies of Cutworms that are often observed.

FIG. 4—Enemies of cutworms that are frequently seen in grain fields. A Fiery Hunter Ground-beetle, B Cutworm Lion which is the larva of A, C Solitary wasp. All natural size. (Original.)

Fiery-hunter Ground Beetle These beetles occur over the entire province. There are several species, all of which are, for the greater part black in colour. Some of them have rows of small metallic red or greenish spots on the wing-covers. They are about ½" long. They run *very* rapidly over the soil and occasionally dig energetically into it with their long legs. When so doing they are hunting for cutworms upon which they feed.

These beetles must not be confused with the rather more slender, slow moving and clumsy black beetles that are common in the southern part of the province. These are the adults of False wireworms (see page 45).

The beetles lay eggs in the soil during the spring. Elongate black grubs hatch from these and grow rapidly till they also are about 1" long. These grubs are called "Cutworm Lions" since they feed entirely on cutworms. They never come above ground.

The number of the beetles and of their grubs that survive from year to year is entirely dependent upon the abundance of cutworms. Their numbers cannot be increased by breeding and liberating them.

Solitary Wasp During the season of cutworm activity these large slender black insects with four smoky black wings, search the ground actively for cutworms. They dig energetically with their long legs when they find a cutworm below ground and soon unearth it. They accurately sting it in such a manner that it will be completely paralyzed, but not killed. Now they drag it to a small hole in the ground in which they bury it and lay an egg on it. From the egg a small white grub hatches that eats the helpless cutworm.

Parasites of Cutworms. The most important parasites of cutworms are reddish wasp like insects, and bristly flies that somewhat resemble common blow flies. Although they are of more importance in killing cutworms than are fiery hunters and solitary wasps, they are less often observed by farmers.

Control Measures.

1 Cultural.

Since all of our injurious cutworm moths lay their eggs only in loose earth summerfallow should never be worked while the moths are flying. The dates of egg laying differ slightly with the various species but the majority of moths are laying eggs throughout August and September.

For this reason fallow land generally speaking, should be *well worked* and be quite *free from weeds* by the end of July. It need not then be touched again during the season. Any subsequent growth of weeds will not mature seed neither will it remove much moisture from the soil. If desired however, cultivation can be resumed after the end of September.

During the "bite" period precautions must be taken to keep stock and people out of the field. Either will break any surface crust that has formed and thus will give moths an opportunity to lay some of their eggs in the field.

Since it is impossible to avoid disturbing the surface of the soil when crops are being harvested during the egg laying period there is no practical method for protecting these fields from the moths. In this connection it should be remembered that the use of a combine after the first week of September will avoid breaking the crust during the period in which most of the eggs are being laid.

When practical during periods of bad cutworm outbreaks, it is advisable to seed wheat only in properly prepared summerfallow. If this cannot be done some benefit can be derived from deep fall ploughing. If this be 6" deep and the furrows are turned completely upside down the majority of the eggs are buried so deeply that few of the very small unfed cutworms will reach the surface in the spring.

2 Bait.

For any cutworms that feed above ground bait *if properly applied* probably will prove to be an effective control measure. For those that feed entirely below ground it will never be of sufficient value to warrant the expense or the labour of employing it.

Formula for Cutworm bait:

Bran	100 lbs.
White Arsenic, or Paris Green	4 lbs.
Molasses	1 gal.
Water	7-8 gals.

Method of Mixing On page 14 is described the method for preparing grasshopper bait. The same procedure should be adopted the only difference being that no sawdust or salt is employed in cutworm bait.

Application when used broadcast. The following recommendations, condensed from Dr K. M King's pamphlet on Red backed Cutworms, apply to all other surface feeding species

"For success *three* conditions are essential *uniform* spreading, application during the *evening* and favourable *temperature* It is essential that a warm, but not too hot, evening be chosen for its application If a thermometer in the shade registers less than 50°F at sundown, it will be too cold for good results, and the bait should not be put out. Particularly good results can be obtained when the soil is moist, hence, whenever it is possible, spread the bait soon after rain if the temperature is suitable."

Not more than 10 pounds of the prepared bait are required to poison an acre, but the scattering must be *uniform*, since many cutworms do not crawl far in search of food

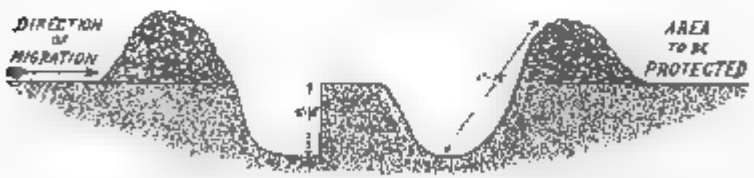


FIG 5—Sections of trap-furrows —A. Vertical sided furrow, for use in damp soil B. Dusty sided furrow for use in dry soil.

Application when used in furrows Whenever it is noticed that any kind of cutworm has the habit of crawling in large numbers across fields, and that they are all moving in approximately the same direction, it is economical in material and in labour to poison them in specially prepared furrows which are ploughed at right angles across their line of march. In addition, much cheaper baits than bran can be employed

Furrows for use with bait are prepared as follows. If the soil be sufficiently moist to permit ploughing a vertical sided furrow a plough with a coulter must be used and the earth thrown out *towards* the advancing cutworms. The furrow should be as deep as is possible, and every precaution must be taken to assure that its side is vertical and undisturbed (see Fig. 5)

More frequently than otherwise such a vertical sided furrow cannot be prepared. Either the soil is too dry or it has been already cultivated so that its side crumbles. Under these conditions a dusty sided furrow will give better results. No coulter is necessary. Plough a deep furrow throwing the earth *away from* the advancing cutworms. Immediately after ploughing, before clods of earth in the furrow have dried out, drag a heavy log along it. One or two horses hitched with a logging chain to one end of a heavy gate post on the rear end of which the driver stands to increase its weight has given excellent results. This breaks up all lumps of earth leaving a fairly steep and crumbly slope (see Fig. 5), which is impassable to cutworms, since the small particles of earth move under them. After a shower of rain, and as soon as the surface crust of earth has dried out, the log must be again drawn through the furrow.

Poisoned bran as recommended for broadcasting can be scattered along the furrow at the rate of 10 pounds to 60 or 70 rods. Though the best results will be obtained when the bait is applied in the evening the furrows can be baited at any time of the day at which cutworms are seen to be attempting to cross it. Even though they would not at the time, feed readily on broadcast bait few of them fail to stop and eat some of it after one or two unsuccessful attempts to crawl up the side of the furrow.

A much cheaper bait can be prepared from green vegetation. In the field, look for any fairly rankly growing weeds on which the cutworms have fed. Stinkweed is a favourite with many of them and lamb's-quarters or pigweed with others. Pull about 40 pounds of this vegetation, place it on a floor and sprinkle water over it till it is thoroughly moist. While turning it over with a fork shake into it, a little at a time, one pound of white arsenic or Paris green.

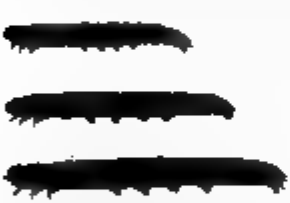
Scatter the poisoned plants 6" to 9" apart along the furrow so that ten pounds will treat about 50-60 rods. Since the vegetation remains moist longer than does bran, it is a preferable bait. The cost of materials, also, is only about 15c per mile of furrow when white arsenic is used.

Reseeding Fields after the crop has been destroyed by Cutworms.

It is never safe to reseed a field in which cutworms have destroyed the crop while the cutworms are still present in it. Some species of cutworms, particularly those which are active on the surface of the soil by day, leave a field as soon as they have eaten all of the vegetation in it. When the damage has been caused by this type of cutworm immediate reseeding is safe, though it is advisable to protect the field with furrows (see page 25) These need not be baited unless, at any time, it is seen that cutworms are attempting to cross them.

Other types of cutworms, however, remain in the devastated fields and eke out a bare existence on old and dead vegetation and by feeding, to some extent, on each other When such cutworms are present it is never safe to reseed till they are mature and have ceased to feed

We cannot give a definite date on which reseeding is safe since, even in the same season, cutworms mature more rapidly in some fields than they do in others.



1" long. Do not re-seed in less than three weeks.

1¼" long. Do not re-seed in less than ten days.

1½" long Full-grown. Sow in about one week's time.

FIG 6—Diagram to assist in ascertaining when re-seeding is safe.

The diagram, given above, can be used in connection with all cutworms in order to determine when reseeding is safe.

Collect a number of cutworms from the soil of the damaged field and pick out a few that are of the *average* size. Drop them into a glass of water. Within ten minutes all will straighten out and appear to be dead. Dry them on a piece of blotting paper and compare their length with the figures on the diagram.

Unsatisfactory Control Measures that are sometimes recommended.

Coal oil, turpentine or any other material applied to the seed has no effect on cutworm activities, neither has lime, salt or sulphur applied to the soil.

Rolling will *never* kill cutworms. If the soil be damp it may slightly hamper their movements below ground. Harrowing has the opposite effect and is harmless to the cutworms.

Seeding with a press drill may be slightly beneficial in some cases, but if the drill is purchased solely for this reason it is unlikely that it will prove to be an economic investment.

Light traps, placed in the field, may capture an enormous number of moths. Since over 95% of these are males and many of the remainder are females which have already laid their eggs, they are of no practical value.

References to Literature on Cutworms in general.

Gibson, A., "Cutworms and their control," Dominion Entomological Branch, Ottawa. Bulletin 10, 1915.

PALE WESTERN CUTWORM (Agrotis orthogonia)

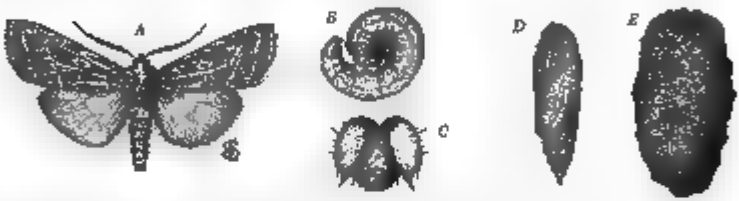


FIG. 7. Pale Western Cutworm. A. Moth (Green ash-grey in colour), B. Cutworm (usually slaty-grey), C. Head of cutworm, enlarged to show smoky black A-shaped mark in front, D. Chrysalis, or Pupa, E. Pupal Cell, composed of earth. (In this figure the moth has already escaped through the hole that it has made at one end). All, except C., natural size. (Original.)

Distribution. The normally treeless prairie of Alberta, particularly in the southern third of the province. There is little likelihood of this cutworm ever extending its range of activity into those parts of our province in which the aspen poplar is native.

Life-history and habits. The eggs are laid only in loose soil during the last three weeks in August and the first half of September. Provided it does not modify the condition of the soil surface, the presence or absence of green vegetation in the field appears to have no effect whatever upon the moths in the selection of places in which to lay their eggs.

The cutworms hatch from the eggs towards the end of April. After feeding above ground for a few days, the small cutworms enter the soil and, under favourable conditions, remain permanently below ground until they are full-grown in early June. Whenever the soil is wet, or if it is very hard,

they are unable to move freely from plant to plant beneath the soil surface. Under these conditions they move, after dark, above ground but burrow into the soil, when this is possible, as soon as they find food.

Special Control Measures.

Summerfallowing. For pale western cutworms, more than for any other species, it is essential that the soil surface be allowed to become crusted throughout August and September (see page 24). During outbreaks of this cutworm this method alone can be relied upon to hold damage in any given field to a minimum.

Use of a test strip of grain in the spring. Fields that had no crust on the surface at the egg laying period are always liable to be infested to a greater or less extent in the following spring. In periods of great cutworm abundance many of these fields may be so heavily infested that any crop seeded early in the season in them is certain to be destroyed. This results in heavy losses that can be avoided only by ascertaining, *before* the field is seeded, the approximate number of cutworms that are present. This can be done by the following method:

Before seeding any of the fields that you believe to be safe, seed two single drill widths of wheat diagonally through the field from the opposite corners. When this wheat is about 4" high examine it for cutworm damage. Remember that the smallest cutworms feed on the *blades* and that small holes eaten into their upper side, or right through them, indicate the presence of cutworms as much as do plants that have been cut at ground level. Seasons find that if on an average 1 to 50 plants to the square yard have been damaged it is not safe to seed the field. It should be summerfallowed or seeded to green feed in June when the diagram (page 27) indicates that seeding is safe.

Choice of crops in fields that are believed to be infested. Pale western cutworms prefer grain to broad leaved plants, such as flax. Flax is however not immune from attack when there is nothing else for them to eat. It is useful for seeding in fields after the cutworms in them have matured. Corn suffers very heavily on account of the comparative scarcity of plants on which the cutworms can feed.

Treatment of fields in which infestation is patchy. Nothing practical can be done to reduce damage in a field that is infested throughout.

In many fields, however, the cutworms may be confined, early in the season, to small areas scattered throughout the field. In the fall most of the field may have borne a crop whereas these areas, which are often on all knolls, had the crust broken by wind erosion or by some other cause. When this appears to be the case, examine other parts of the field for damage to the blades or for evidences of a few plants having been cut. The reason for so doing is that the eggs are laid, but hatch a little earlier, on the higher and drier parts of the field than they are elsewhere, and the infestation may be general although apparently confined to these areas. If, however, the rest of the field shows little or no sign of damage, plough a deep furrow around the badly infested areas. This will help to prevent the cutworms from spreading through the field. It cannot stop them entirely, but it may reduce the spread by 50%. Under these circumstances it is also a sound practice to scatter some poisoned bait in the heavily infested areas and to harrow it into the soil before the furrow is ploughed around it.

Forecasting outbreaks of pale western cutworm. Much loss from these cutworms could be avoided if farmers knew when to expect outbreaks in order that they could give especial attention to their summerfallowing methods during the previous summer. It has been shown that outbreaks are due to lack of rainfall in the previous May and June. Swaine has prepared a rough guide that can be used by all farmers in order to find out whether cutworms are liable to increase in numbers in their district. The following is a quotation from his pamphlet: "One quarter of an inch of rainfall is sufficient to bring the cutworms to the surface of the ground. If the sun is bright after rain they seek shade and are lethargic, but if the weather remains cloudy they may become active and behave very much like ordinary surface feeding cutworms. It has been found that when the fields are too wet to use a disc harrow the cutworms are also likely to be on the surface and a day with the soil in such a condition, whether raining or not must, therefore, be considered as a wet day in forecasting. When it is not actually raining, an observation in the field will be required to determine the moisture condition of the soil.

"If there are less than ten 'wet' days during the period of cutworm activity there will be an increase in the number of cutworms the following year.

"If there are between ten and fifteen such days, there will probably be some decrease in the numbers of cutworms next year.

"If there are more than fifteen 'wet' days, little trouble may be looked for from this insect the following year."

In this connection we would point out that this refers only to the increase or the decrease in numbers of cutworms from year to year. If, in any year in which there were less than ten "wet" days during the period of cutworm activity, cutworms were already sufficiently numerous to be causing appreciable damage, a serious outbreak can be anticipated in the following year. When however, cutworms were very scarce the same number of "wet" days probably will not result in serious consequences. At least two successive seasons that are favourable to cutworm increase are usually necessary before a serious outbreak occurs.

References to Literature on Pale Western Cutworms

Seamans, H. L., "The Pale Western Cutworm." Entomological Branch, Ottawa. D. of A. Pamphlet 71, 1931

RED-BACKED CUTWORM (Euxoa ochrogaster).

Distribution. Outbreaks of this cutworm are most frequent in those parts of Alberta in which the aspen poplar is native. It may, however, occur, though less frequently in destructive numbers, anywhere in the province.

Life history and habits. The eggs are laid in the soil during the last week in July till the end of August. From this it will be seen that the moths begin to lay their eggs *about two weeks earlier* than do those of the pale western cutworm.

We have never observed egg-laying in the field. The reason for this is that the moths apparently lay them only after dark. When they are confined in cages these moths lay all their eggs in the soil and, under these conditions, they deposit them in the loosest soil that they can find. They thus appear to have somewhat similar habits to the pale western cutworm moths.

In the field we can ascertain where the majority of eggs have been laid only by observing where the young cutworms are most numerous in the spring. Later in the season half-grown cutworms move freely from place to place. All of our observations in this connection indicate that the moths lay their eggs, whenever it is possible, *in the vicinity of* vegetation that will provide suitable food for the cutworms in the spring. The condition of the soil surface appears to be of less importance than it is in the case of the pale western cutworm. No field in which the soil was slightly crusted in the latter part of the summer has ever been found to be infested in the following spring provided it was free from green vegetation

during the egg laying period. On the other hand, we have no definite records of really clean summerfallow that was being worked at the time of egg laying being seriously infested.

The favoured food of this cutworm includes a variety of broad leaved plants. Sweet clover, alfalfa, a great variety of garden produce and weeds such as stinkweed are attractive to the moths during the egg laying period. Where these grow in profusion it would appear that a slight rust on the soil surface fails to deter the moths from laying their eggs among the plants. In the outbreaks which occurred in separate years, we have examined the distribution of young cutworms in the early spring on the Dominion Experimental Farms at Lacombe and at Beaverlodge. The repetition of comparatively small plots which are carrying different crops and which have received a variety of cultural treatment offers a good opportunity for observing where the majority of eggs have been laid. Sweet clover, whether it has been worked or not since midsummer, was invariably infested, whereas crops worked into summerfallow that was really clean during the previous summer were practically free from these cutworms.

Elsewhere we have observed that fields which contained much stinkweed even though they became crusted on the surface in July and August were severely infested with red backed cutworms in the following spring. In these fields, it should be noted the crust had apparently provided a complete protection from the pale western cutworm moths, which were also very abundant in the district.

The cutworms hatch from the eggs towards the end of April. They are mature by the middle of June. Unlike the pale western cutworm they are liable to come to the surface of the soil quite freely even by day and to feed on the surface almost as much as they do from below ground. As was stated earlier they prefer broad leaved plants to grass. When, however, large numbers of eggs have been laid in a field that was later worked to wheat or other grain they will feed on it at least until they are sufficiently well developed to move elsewhere in search of something more to their liking. They are less restless and feed more extensively when they are in barley or oats than when they are in a wheat field. In the latter by the time they are half grown they frequently come to the surface by day and move rapidly all travelling more or less in the same direction, over the surface of the soil.

Special Control Measures.

Summerfallowing Summerfallow should be *absolutely clean* by the middle of July, and should then be left alone till the end of August in order to take advantage of any crust that may form If the field contains much green growth and is merely cultivated in August it will, in all probability, be rendered very attractive to the moths, since much of the vegetation is not covered and the soil surface is loosened up.

Bait Since these cutworms feed above ground as well as from below, poisoned bait, under favourable conditions of application, will often prove to be of value. Read carefully the *only* conditions under which bait can be successfully employed on page 25.

At any time in which the cutworms are seen to be moving towards or through a grain field over the soil surface, large numbers of them can be destroyed by the use of baited furrows ploughed across their line of march (see page 25) In this connection we have obtained the best results by employing stinkweed bait.

Choice of crops in fields that are believed to be infested. Since broad leaved plants, such as flax or sweet clover, are preferred as food by these cutworms, it is advisable to seed grain in fields in which they are believed to be present Wheat is the safest grain to grow since, although the small cutworms feed as freely on it as they do on barley or oats, as they grow larger they attempt to move elsewhere. Furrows for baiting should be prepared around the edges of badly infested wheat fields in order to trap and to kill any cutworms which attempt to leave them and to enter neighbouring fields.

References to Literature on Red-backed Cutworms.

King, K. M., "The Red-backed Cutworm and its control in the Prairie Provinces," Entomological Branch, Ottawa, D. of A. Pamphlet 99, 1927

ARMY CUTWORM (Chorizagrotis auxiliaris).

Distribution. This cutworm has appeared in numbers, sufficient to constitute a serious menace to grain fields, only in the extreme south of Alberta. It is, however, widespread throughout the province, and during recent years has been far more numerous than formerly as far north as the Peace River District.

Life history and habits. The eggs are laid in the soil during September. They hatch a few days after they are laid.

The cutworms beg n immediately to feed on any green vegeta tion that is present in the fields at that time of the year They grow rapidly, and are half grown by the time the soil freezes up. They remain inact ve just beneath the soil till the following spring and, as soon as the frost is out of the ground, they come to the surface and move around in search of food Army cutworms *never* feed be ow ground, but tend to cl mb up plants and to feed on the blades. When food is plentiful they remain below ground by day an l come to the surface and feed only at night When, however, food is scarce they may be very active by day and, if the sun is shining, they will all move in a *northerly direction* in search of food

Since all feeding is done from above the surface and is confined largely to the blades, individual army cutworms d less damage than do those species which cut off the plants at the base It is only when they are very numerous that they are liable to ruin grain crops.

Most of the cutworms are mature by the first week in June.

Special Control Measures.

Summerfallowing. Outbreaks of army cutworms gener ally develop far more rapidly than do those of other cutworms. They are unlikely to last for more than one year Farmers, therefore, rarely have any warning with regard to when to expect them Since the eggs are laid in freshly worked soil a crusted surface in September will protect individual fields. It must be remembered, however, that at any time during the spring, fields that were free from eggs in the fall may become infested with migrating army cutworms.

Bait Where these cutworms are numerous they are usually first observed when the fields are being prepared for seeding early in April. They are then from ½" to 1" long. If, at that time, care is taken to *bury all green vegetation* nearly all of the cutworms will have left the field before the wheat i above ground. Precautions must, however, be taken to protect the field from later invasions, particularly along its southern side. This can be done by preparing and baiting furrows as described on page 25 Stinkweed has proved to be superior to bran for the bait, and we would recommend its use wherever it is available Either one furrow, or two of them at a distance of about a rod apart, should be ploughed along the edge of the field Scatter the bait at any time of the day in which the cutworms are seen to be entering the furrows in

large numbers, and replenish it every three days for as long as migrations continue.

When the cutworms are found to be already present in large numbers in growing grain they can be readily controlled with bait broadcast as described on page 25.

Cause of outbreaks. The moths of the Army cutworm lay about 1,000 eggs. This is greatly in excess of the number that are laid by those of any other common cutworm. This accounts for the sudden appearance of the pest. Seamans has shown that, if the soil be dry when the eggs are laid and it remains so for a few weeks, most of the eggs perish. In a wet fall, however, nearly all of them hatch, with the result that the cutworms are very numerous in the following spring. Since it is unusual for southern Alberta to experience two wet falls in succession, outbreaks of the Army Cutworm are usually terminated as suddenly as they occur.

References to Literature on Army Cutworms.

Strickland, E. H., "The Army Cutworm," Dominion Entomological Branch, Ottawa. Bull. 13, 1916.

Seamans, H. L., "The Army Cutworm," Entomological Branch, Ottawa. D. of A. Pamphlet 102, 1929.

EARLY CUTWORM (Euxoa tristicula).

Distribution. The open prairie areas of Alberta, particularly in the south.

Life history and habits. Eggs are laid in the fall and they hatch a few days later. The cutworms feed on weeds and are nearly full-grown by the time the soil freezes up. As soon as the frost is out of the ground in the spring they resume activity. They mature at about the middle of May.

Although these cutworms can be found in the fields every spring they have never been very numerous in Alberta. They prefer weeds to grain and, in the small numbers in which they have occurred here, we consider them to be very beneficial since they harbour many parasites that later attack and reduce the numbers of the more injurious cutworms. In addition, they are usually through feeding before any seeded crops are above ground. King states, however, that they were unusually abundant in several localities in Saskatchewan in 1925, and that they caused serious injury to grain. When they are observed in large numbers he recommends delaying seeding till about the last week in May. Poisoned bait is not effective for the control of this cutworm.

GLASSY CUTWORM (Sidemia devastator)

Distribution. The entire province. The moths of this cutworm are very abundant every year, but the cutworms have never been found in very large numbers in grain fields.

Life-history and habits. It is not known for certain where the majority of the eggs are laid. It has been suggested that they are laid, by preference, on or in the vicinity of grass, though there is a record of their being laid at the base of a tree. In Alberta we have found these cutworms in the largest numbers in brome sod, where they do comparatively little damage.

Although they occur sparingly in clean grain fields, we have found them in destructive numbers only in fields in which an unusually large amount of grass was present. In this connection, Criddle found that, in Manitoba, they feed on grass such as wild barley grass in preference to grain.

The eggs hatch soon after they are laid, and the cutworms are nearly full grown by the time the ground freezes up. In the spring, if no grass is available, they feed freely on grain. They rarely come above the surface of the soil, but pull entire plants into the ground and there feed on them at their leisure. These cutworms mature before the end of May.

Special Control Measures.

Since the greatest damage from these cutworms appears always to be associated with the presence of grass during the egg-laying period, care should be taken to cover sod completely when it is being broken. The same precaution should be taken when cultivating summerfallow in which much grass is present.

Bait is useless for these cutworms, since they come to the surface even less than do pale western cutworms.

References to Literature on Glassy Cutworms.

Gibson, A., "Cutworms and their control," Dominion Entomological Branch, Ottawa. Bulletin 10, 1915.

WIREWORMS.

There are a large number of different species of wireworms in Alberta. Over 80 different kinds of click-beetles, into which wireworms develop, have been captured in our province. Nothing whatever is known of the habits of most of these as wireworms. Of those that are known, several are certainly harmless to grain since they live only in decaying

wood. About ten different kinds of wireworms have been found in grain fields. Three or four only ever occur in sufficient numbers to cause appreciable damage, and of these one only is a widespread pest of grain crops in Alberta. This is the Northern Grain Wireworm.

A second species, which has no common name and which is very much smaller, is often associated with it in fields in which there is much sod, while a third, which is also very small, is sometimes very destructive in the extreme south of the province.

NORTHERN GRAIN WIREWORM (Ludius aeripennis var tinctus).

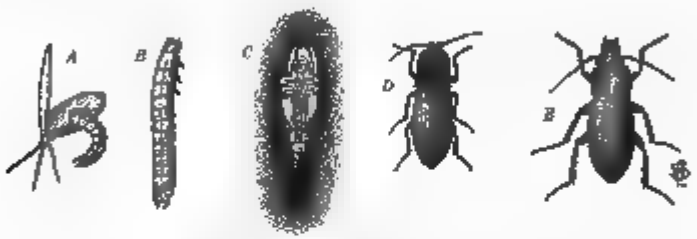


FIG. 8—Northern Grain Wireworm. A, Half-grown wireworm attacking grain, B, Full-grown wireworm. (Note the flattened plate with two double claws at the end of the body), C, Pupa in cavity in the soil, D, Adult Click-beetle or Wireworm. Do not confuse with E, a fast-running ground-beetle, which feeds on very young wireworms. Ground beetles vary much in shape, but they never have the two backward-pointing spines, one on each side, near the middle of the body. All figures natural size. (Original.)

Since we have little information regarding the two smaller species of wireworms, we will confine our attention particularly to this widespread grain pest.

Distribution. Widespread throughout the province, but rarely encountered in destructive numbers anywhere except in the central part of Alberta and in the Peace River District. Although it is quite common throughout the southern part of the province, it is less abundant there than it is farther north, and is usually associated with other species of wireworms and with False wireworms, with which it is liable to be confused. In those areas of Northern Alberta that were originally fairly densely covered with trees or bushes it rarely occurs in sufficient numbers to cause appreciable damage.

Length of life. In the case of most insects the life-cycle is completed in a single year. It is important to bear in mind

that this is *not* the case with wireworms. We cannot state with any certainty for just how long these pests live when they are in grain fields. In the laboratory their length of life varies considerably. Three years appears to be about the minimum. Others have lived for six years and are not yet mature. The importance of this will be realized when an effort is made to reduce their numbers. It will be realized, also, that the total number of wireworms in any field is not likely to vary to a great extent from year to year. When damage in the same field varies greatly from year to year this is attributable more to variations in the amount of feeding than it is to the number of wireworms that are present in the field.

Life-history. The beetles lay about 300 eggs in the soil during May and June. Minute wireworms hatch from these in about one month's time. They grow slowly during the next few (possibly 3 to 8) years. However many years old they may be, they all mature at about the middle of July. Then at a depth of less than 5" from the soil surface, they make small cavities in the soil, and in these transform to helpless, very soft, white pupae. Within three weeks these have again transformed into beetles, which remain inactive in the soil till the following spring.

Habits of Wireworms in all stages of Development.

Beetles. These are known as "click beetles" or "snappers," because if they are placed on their backs on a smooth surface they soon jump into the air with an audible "click." No beetles other than those of wireworms do this.

Although they normally remain inactive in the soil throughout the winter, they are not harmed if they are disturbed by fall ploughing.

In the spring, as soon as the soil warms up in March or April they struggle to the surface and on fairly warm days, they wander over the fields. The egg laying females *never fly*. They probably rarely move very far from the place where they lived as wireworms before laying their eggs, since they often retrace their steps.

Egg-laying. Late in May and throughout June the females make frequent trips into the soil for the purpose of egg laying. Depending upon the temperature, moisture and firmness of the soil at this time, they deposit eggs at any depth from just below the surface to 5 or 6 inches deep. One beetle in captivity made eleven such trips in a month and laid a total of 252 eggs.

Eggs that are laid very near the surface of the soil rarely hatch since at some time before they normally would do so, they are dried out or are killed by heat. It would appear that, on average seasons, eggs laid at less than 2 inches from the surface are in danger of destruction in this manner. On the other hand eggs that we have placed 5 or 6 inches deep in the soil have never failed to hatch.

Food requirements of very small wireworms. As soon as the very small wireworms hatch they burrow in the soil in search of food. If within about a month they fail to find any that is suitable nearly all of them will have died of starvation. This is a long time for them to be able to live without food but the fact remains that, at that time, they can be starved. After passing their first winter they can live for at least two years without food other than humus which is universally present in soil. From this the importance of starving half grown wireworms by clean summerfallowing will be appreciated.

The question naturally arises as to what constitutes a satisfactory source of food for newly hatched wireworms. Germinating grain and the roots of grain and of many grasses certainly supply their needs. It is very doubtful whether the seeds or the roots of many weeds will do so. In the laboratory they fail to survive when offered such plants as shepherd's purse, tumbleweed, lamb's-quarters and many other weeds on which older wireworms feed freely. A few have survived on flax and on Russian pigweed but the presence of living grain or grasses appears to be essential if many of them are to do so.

Feeding habits of older wireworms. When the ground freezes up all wireworms become entirely inactive till the following spring. Their habits are the same from year to year. As soon as the ground warms up they resume activity. When a field in which they are present has been seeded with grain they attack the seeds and eat out the starchy food material that they contain. The plant is thus starved and it fails to come above ground. Very small wireworms frequently eat only the embryo, particularly if the soil is inclined to be dry. The result is the same, the plant does not appear above ground.

Having destroyed one seed the wireworm moves, usually along the drill row, and destroys the one next to it. In this manner a single fairly large wireworm may prevent a dozen or more adjacent plants from appearing above ground. A little later in the season, when undamaged plants are above

ground, the wireworms turn their attention to the stems and bite through them well below ground level. Plants attacked in this manner do not fall over, as do those that are killed by cutworms. The leaves wither and become tightly rolled up. This is very characteristic of wireworm damage.

Still later, when the plants are beginning to stool out and the stems are becoming thicker and tougher, the wireworms no longer cut them off completely. They bite a small hole through to the central shoot and feed on it only. As a result the central leaves of the plant turn yellow and die, though the older ones may show no sign of damage above ground.

At about this time, which is early in June, the wireworms tend to leave off feeding. By the time the plants are fully stooled out little further damage is seen.

It is important that we understand why damage is reduced or entirely ceases in June, even though the wireworms are still present in the field. Wireworms *never* come above ground. They feed only in *fairly cool moist earth*. Early in the spring they are able to come, and to feed, nearly at the surface of the soil. As this dries out and heats up later in the season they burrow more deeply to cooler, moister earth. By the middle of June, in normal seasons, they are below the level of the seed, and such feeding as they do is confined to the roots which, as a rule, are not very seriously injured.

Pupation.—By the middle of July all full grown wireworms work their way upwards in the soil and come to rest at about two to four inches from the surface, provided the soil is not too hot and dusty for them to make a small cavity in the ground in which to pupate. Here they soon turn into delicate white pupae that are very easily crushed if the soil that surrounds them is disturbed. When, early in August, these have turned into hard-shelled beetles they are very difficult to destroy.

Control of Wireworms.

Methods for reducing wireworm damage fall into two main categories:

1. Reduction in the number of wireworms that are present.
2. Reducing damage to the crops even though the number of wireworms that are present cannot be reduced.

It is obvious that the first is the more desirable. Effective methods for killing wireworms have been developed in truck raising districts where land is frequently valued at $1,000 an

acre. This valuation warrants excessive expenditures in maintaining productiveness. Such methods, which cost in the neighborhood of one to three hundred dollars an acre, are out of the question for grain raising.

No entirely satisfactory method for destroying wireworms in grain fields, or for reducing the feeding activities of those that are present, has been discovered. There are, however, a number of different methods, each of which affords some measure of relief. By employing *all* of them damage may be appreciably reduced.

Cultural methods for reducing the number of wireworms. In districts that are infested with wireworms it is usually in the fields that have been for the longest time under cultivation that damage is most severe. There are, of course, exceptions to this rule. Wireworms are native to Alberta. In virgin sod they appear to thrive only where the soil is unusually loose and damp. Where such areas occur they are referred to locally as "loose top." They usually are comparatively small, some two to three rods in diameter.

When a field that contains areas of "loose top" is first broken and seeded to wheat, the crop in these areas may be completely destroyed by the large number of wireworms in them, while there is little damage throughout the rest of the field. After a few years of cultivation, however, the wireworms become spread throughout the field. This spread is usually accompanied by a serious increase in their numbers.

Experiments indicate that one reason for the abundance of wireworms in "loose top" is that the natural condition of the soil in such areas is ideally suited to the requirements of egg laying beetles. These beetles are unable to burrow into firm earth. In hard virgin sod they fail to penetrate into the soil to a sufficient depth in order to safeguard their eggs from destruction by heat and desiccation. In "loose top" they can, however, burrow readily to five or six inches, at which depth all of the eggs they lay are practically certain to hatch.

The usual practice employed for summerfallowing is to plough deeply in May or June. This is just before, or at, the time when the beetles are laying their eggs. By this method the soil texture of the entire field is modified into "loose top", and the beetles can burrow readily to plough depth. It is preferable to keep the sub-surface soil as firm as is possible during the egg laying period, in order to induce most of the beetles to lay their eggs in the superficial layers.

It should be remembered, also, that during the *last half of July* all *mature* wireworms turn into helpless pupae. These are located as near to the surface as it is possible for these wireworms to make a small cavity in firm earth. Pupae are readily destroyed if the soil that surrounds them be disturbed. At no other stage in their development can wireworms be destroyed *mechanically* with a cultural implement. It is only at this time of the year, therefore, that deep ploughing is of value in reducing their numbers by mechanical destruction.

We recommend, therefore, the following modification in summerfallow methods in fields that are badly infested with wireworms.

1. Early in the spring, cultivate to a depth of not more than 2½"; the shallower the better. This will encourage the germination of weed seeds that are near the surface.

2. Repeat shallow cultivation, as often as is necessary to *destroy all weed growth*, till the middle of July. This loosens the surface and packs the ground to some extent below the depth of operation, thus encouraging shallow oviposition. Early in the season wireworms are near the surface and many of them are exposed to destruction by birds. Each operation, also, brings many of the eggs that are laid in the loose earth right to the surface, where they are certain to perish, and it also tends to aerate all of the worked soil. Finally it should result in the germination and destruction of all volunteer grain on which any small wireworms that manage to hatch thrive better than on anything else.

3. During the last half of July plough to a depth of at least 5". This will destroy many of the pupae that are lying near the top of the firm soil. It is essential that ploughing be not delayed till August. The beetles are then formed, and they will be in no way damaged by the ploughing.

This method aims at destroying as many eggs as is possible, at starving most of the newly hatched wireworms, at exposing as many half grown wireworms as is possible to birds, and at destroying pupae from which would have developed the beetles which lay eggs in the following year.

It must, however, be borne in mind that summerfallowing by this method cannot have a very marked effect on the number of destructive wireworms that will be present in the following year. The greatest damage is done by wireworms that are from three to five years old, and their numbers will

not have been greatly affected The best that can be claimed for it is that it tends to *reduce* the steady increase in wireworm numbers rather than to *increase* it.

Cultural methods for reducing wireworm feeding As has already been pointed out, wireworms, except when they first hatch, cannot be starved Furthermore, when conditions in the field are not favourable for feeding, they eat very little. Maximum feeding takes place in soil that is quite damp and fairly cool. Firm soil retards their movement in search of food.

We have experimented with the use of press drills, packers, and seeding at different depths and dates in order to ascertain their effect on wireworm damage. This work was conducted at the Dominion Experimental Station at Beaverlodge through the courtesy of the Superintendent, Mr W D Albright, and with the aid of a grant made for that purpose by the Dominion Research Council.

Although carefully checked experiments were conducted during one season only and the results were not very conclusive, they tended to confirm those that have been obtained by other investigators. They are as follows

1 Seed only in a well-prepared seed bed in which moisture is close to the surface.

2 Seed as shallowly as is possible with the assurance that the seed is well down to moisture.

3 *Combined with shallow seeding*, use a press drill, or press-attachment, or else pack at right angles to the drill rows immediately after seeding In our experiments we found *more* damage when grain was seeded 4" to 6" deep with a press drill, or when it was packed, than there was when it was simply seeded at similar depths with a disk drill It was only when it was seeded 2" deep that pressing or packing produced any benefit. We cannot state whether this will always be the case, but hesitate to recommend the use of a press-drill or a packer except in the case of shallow seeding.

4. Grain seeded as late as the middle of June is not likely to be damaged seriously Wireworm feeding is nearly over for the year by this time It is useful to bear this in mind in connection with reseeding, even though it is then too late to reseed with wheat.

It is impossible to state, for all seasons, whether early or late spring seeding is advantageous. When the soil is really

cold wireworms hardly feed at all though at the same temperature the grain is softening prior to germination. This gives the grain a start so that it can grow rapidly when the soil warms up. If however the soil remains somewhat cool, and subsequent growth is slow the wireworms have longer to feed on the germinated grain and small plants. Generally speaking early seeding is preferable but *rapid growth* is a matter of great importance in reducing damage.

Use of Fertilizers. Everything that is possible should be done to encourage rapid germination and *development* of the plants. In many districts in Alberta there is a serious shortage of phosphates in the soil. Phosphates encourage early development of roots when they are applied at the time of seeding. This makes the plants more resistant to wireworm damage. Where phosphate shortage is indicated it has been found to have a marked effect on wireworm damage. At Beaverlodge Mr. Albright finds that application of phosphates do not have as great a rating an effect on wheat as they do in some other districts and their application did not appreciably reduce wireworm damage.

Treatment of the seed or of the soil with chemicals to reduce wireworm damage. Claims are made frequently to the effect that grain treated with coal oil, turpentine, lime, tar and a variety of other materials is less subject to wireworm damage than is seed not so treated. When these materials have been tested under experimental conditions none of them has been found to be of the slightest value for this purpose. Several retard germination and do more harm than good. In all fairness to those who make these claims it should be remembered that on account of variations in climatic conditions, the amount of wireworm damage varies greatly from year to year. Fields that are selected for these experiments are almost invariably ones that have suffered abnormally heavy damage during the previous year. A perfectly normal decrease in damage during the following year is naturally attributed to the treatment that has been employed, even though it has nothing whatever to do with it.

Copper carbonate when employed for preventing fungous diseases, has no effect on germination, whereas formalin is inclined to retard it. For this reason copper carbonate is preferable to formalin, though it has no direct effect on the wireworms.

A few materials can be applied to the soil in order to kill wireworms that are present. None, however, the cheapest of

such materials cost in the neighbourhood of a hundred dollars an acre in materials and labour, they are of no significance to the grain producer

References to Literature on Wireworms.

Strickland E. H., "Wireworms of Alberta," University of Alberta, 1927

FALSE WIREWORMS (Elasodes hispilabris).

FIG. 9. False Wireworm. A. Full-grown False Wireworm. (Note that under end of the body is pointed), B. Adult Beetle standing on its head as it does when it is disturbed. These beetles must not be confused with the rapidly running Fiery Hunters (see Fig. 6) Natural size. (Original.)

Distribution. These are rarely seen anywhere except on the open prairie. Most abundant in the south and east, where rainfall is light.

Life-history and Habits.

Beetles. Very clumsy black beetles, about 1" long. They walk slowly and have the ridiculous habit of standing perfectly still on their heads when they are mildly alarmed. In addition to this, they frequently fall into gopher holes, and take so long to drag themselves out that many people think they must have some relationship with gophers. Young beetles first appear above ground in late summer. They feed on the foliage of a variety of weeds till the weather turns cold, when they wander extensively over roads, etc., in search of suitable places in which to pass the winter. The most favourable location for this purpose is under dense masses of dead weeds. Here they remain till the spring, when they resume activity and feed on young Russian thistle and other weeds. At about the middle of June they lay eggs just below the surface of the soil, but continue to live till the following fall, or even longer.

False wireworms. The larvae closely resemble wireworms. They are, however, cylindrical and the end of the body is rather sharply pointed. The best character for distinguishing them is, however, their extreme activity. Place

one on the open hand. It will immediately whip its body around in all directions till it succeeds in jumping to the ground, into which it will immediately burrow. No wireworm does this.

Young false wireworms that hatch from eggs in July are half grown by winter. In the spring they feed in a somewhat similar manner to wireworms, though they do far less damage. They are mature by August when they pupate in the soil and soon turn into beetles, which come to the surface immediately and feed on weeds till low temperatures force them to seek winter quarters.

Economic Importance.

False wireworms do comparatively little damage. They attack grain less extensively than do true wireworms, and they appear to prefer nibbling at the roots to feeding on the stem. There are several different species of false wireworms, and Criddle has observed, in Manitoba, that some of them come above ground at night and feed on the blades and stems of grain plants. We have not noticed this in Alberta, though doubtless the habits are the same here as elsewhere. Such damage as they do renders it advisable to keep down their numbers in so far as is possible.

Control Measures.

The most practical control measure for false wireworms is that of keeping the soil surface as free from dead vegetation as is possible during the winter. Abnormal abundance of false wireworms in any field can nearly always be traced to large quantities of Russian thistle or mustard, particularly two winters previous to their greatest abundance. In no stage of development can false wireworms be starved. They can be bred from egg to adult in damp soil which contains no living vegetation. It is possible that this accounts for their causing much less damage than do wireworms. They never *require* living plants for food.

WHEATSTEM SAWFLY (Cephus cinctus).

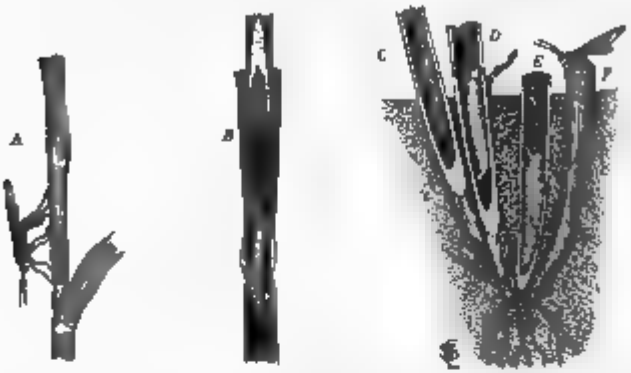


FIG 10—Wheat stem Sawfly.—A Sawfly laying an egg in a young wheat plant, B Grub inside straw It has just eaten through a solid node Note the "sawdust" that partly fills the straw, C An uninfested straw, D Grub cutting infested straw at harvest time E Grub which has plugged the straw stub with "sawdust" and has made a cocoon within which to pass the winter, E Sawfly escaping from stub in the spring after pushing out the plug of "sawdust." All figures natural size (Original.)

Distribution. The present distribution of this pest is in the eastern half of Alberta about as far north as Camrose. It is improbable that it will spread much further northward, but it is likely that it will gradually extend its territory in the direction of the foothills to the west. In this connection, it should be noted that the sawfly is found all over Alberta, including the Peace River District. Elsewhere than in the south and east of the province, however, it attacks grasses only, and there is little likelihood of it becoming a pest of wheat.

Life-history and Habits.

Sawflies The adult sawfly is a small black and yellow wasp-like insect with dark wings. It is about 1/3" long. Sawflies first appear on the wing late in May, and they continue to fly till the middle of July They are very inactive, and spend most of their time resting on stems of grain or grass. When they do fly, they remain near the ground and travel only a short distance before re-settling. In so far as is known, they require no food other than water

Egg-laying The majority of eggs are laid in June, though in some years many are still being laid as late as in the middle of July

The sawfly settles head downward on the young wheat plants and, with a pair of saws at the end of her body she cuts a slit through the leaf sheath into the flowering stem somewhere below the developing head. Through this slit she forces a small white egg. Any number of sawflies will lay their eggs in the same stem. This is an important thing to remember in connection with control. One of the grubs that hatches from these eggs will eventually kill all the others that hatches from these eggs will eventually kill all of the others that are present. From this it is evident that the more we can crowd the sawflies at egg laying time, the greater will be the mortality among the grubs.

Grubs. The small grubs that hatch from the eggs burrow downwards within the hollow straw and eat their way through the solid nodes in so doing. The straw through which they have passed, is partly filled with a sawdust like material. The head, meanwhile, develops normally. Though, as has been shown by Seamans, there is some reduction in the yield of attacked stems this is not very serious. By the time the head begins to ripen, all of the grubs are below ground inside the straw. They now turn round, so that their heads are uppermost, and cut off the straw at a point that is usually about 1" above the ground.

After plugging the open end of the stub with "sawdust," the grub spins a delicate silken cocoon in which it remains more or less inactive until the following spring, when it pupates and later escapes as a sawfly by pushing out the plug.

Plants that are attacked.

Originally sawflies laid their eggs only in native grasses. Now, however, they lay them as readily in all grain crops. The grubs can mature successfully only in *spring wheat*, in *spring rye* and in a variety of native and cultivated *grasses*. Although eggs are laid freely in oats the grubs that hatch from them die almost immediately and do no damage to the crop. They live somewhat longer in barley, but very rarely mature.

Effect of Climate on Sawfly abundance.

Generally speaking, moderately dry seasons are favourable to sawfly abundance. Not only do they do more damage in such seasons, but they will be present in increased numbers to attack wheat in the following year. Excessive moisture, or extreme drought, in June and July reduces their numbers;

but once they have appeared in a district they will always be present in sufficient numbers to cause severe losses when climatic conditions are favourable to them

Cultural Methods for destroying Sawflies.

Deep fall ploughing Since every sawfly that has bred in wheat passes the winter in the stubble, it has been considered that if, in the fall, the infested stubble be ploughed into the ground with a mouldboard plough, few of the sawflies will be able to escape in the spring Our own experiments have proved that fall ploughing destroys very few sawflies. It, however, greatly retards their development in the spring. This delays egg laying, and for this reason it is beneficial. Spring ploughing has little effect

Fall Cultivation In those areas in which snowfall is light, *shallow* fall cultivation gives better results than does deep ploughing. The object of such cultivation is to drag as many of the infested stubs to the surface as is possible and to leave them exposed throughout the winter Only in those stubs that are entirely exposed will the contained grubs perish. The cultivator should, therefore, be set to work no more deeply than is necessary to drag them out.

Stubble burning will not destroy the grubs. They are too far below ground to be affected by the heat even when a stubble burner is employed.

Rotation of Crops and Trap Cropping.

Rotations *Never seed wheat in a field in which sawflies damaged the crop in the previous year* To do so in a field that has been simply spring ploughed will increase the damage in so far as it is humanly possible so to do. It is hardly less safe after fall cultivation or ploughing. Grow wheat only after clean summerfallow, or after some immune crop such as oats, barley or flax that was *free from volunteer wheat.*

Trap crops All clean wheat fields should be protected from invasion by egg laying sawflies with a trap crop seeded around their edge.

In May and June, when recently emerged sawflies are seeking suitable stems for egg-laying, they fly near the ground till they reach a growth of grain or grass that is about 6" or more in height Having found this, they move very little again, but remain in it till they have laid their eggs. If they enter the edge of a well-advanced wheat-field they usually

lay nearly all of their eggs within the first two rods from the edge. If however the field be backward they may scatter throughout it before the plants are of a sufficient height to attract them for egg laying. Thus the whole field is liable to be affected with a consequent loss on the earliest developing kinds. Farmers cannot avoid trouble with any certainty by seeding either earlier or later than their neighbours.

A trap crop grown around the edges of the field is the most certain method for reducing infestation. This consists of a more vigorous growth of a suitable grain or grass than that in the field to be protected.

Brome Grass seeded along the headlands and fence rows, is the most effective permanent trap crop that can be grown. It is very attractive to the sawflies for egg laying and it makes the necessary vigorous growth in the spring. When sawflies are abundant they lay many eggs in almost every stem of this grass. In the protected field each of these eggs might have been laid in a separate stem. At the most one grub only can survive in each stem but in Brome this single surviving has a poor house to shelter. Many die a natural death in this grass as they do in barley. Many more are killed by other insects, their parasites. The heavily infested trap crop of brome will not, therefore breed many sawflies, but it probably will produce a large number of parasites. Unfortunately these parasites which attack sawfly grubs in brome are far less successful in attacking those that inhabit wheat. Mr. Seamans finds however that if the grass be cut for hay at about the middle of July parasitism will increase in nearby wheat. This is due to the fact that the parasites have two generations a year and that the second generation are seeking sawfly grubs in which to lay their eggs at this time.

The greatest advantage from seeding brome along the fence rows is that once it is established and if rotation of wheat with any other crop or with summerfallow be practised, the wheat stem sawfly will be permanently held to comparatively harmless numbers in all fields so protected. In addition, it must be remembered that the brome will yield valuable fodder in the normally useless land and that it crowds out many weeds which otherwise would grow there.

Oats or Wheat can be employed for *temporary* trap crops. Each has its advantages under different conditions. In either case the trap crop consists of a single drill width of grain seeded as early as possible around the edges of the field to be protected. It is essential that it be well in advance of the

wheat in the field when the sawflies are flying at the end of May and in June.

Oats have the advantage that all sawfly grubs from eggs laid in them perish. As a result there is no necessity to cut them before they are ripe.

Wheat has the advantage that in certain seasons the stems lengthen more rapidly in early spring than do those of oats. When the season is such that early development is slow, or trap crop seeding is of necessity much delayed an oat trap may not be sufficiently advanced to prevent the sawflies from flying through it before the end of May. Another advantage is that there is no danger of oats being mixed with the wheat crop at harvest time. This can, however, be eliminated by seeding an oat trap around infested stubble instead of around the neighbouring wheat field to be protected. The main disadvantage of wheat as a trap crop is that it must be cut for green feed by the middle of July in order to destroy the sawflies that it harbours. This reason alone renders oats in most seasons preferable to wheat.

Cutting Wheat on the "Green Side."

Sawfly grubs sever the straw only when the latter is beginning to dry out at the base. At this time, whatever the rate of maturity, the grain is beginning to ripen. It is possible to harvest a *uniformly maturing* field just ahead of the appearance of sawfly damage without causing serious shrinkage. In this manner most of the damage can be avoided. Experience alone will inform the farmer of the first day on which he can begin to cut. He will, however, have only about four or five days during which he can harvest in safety before the grubs begin to cut down infested straws. It is necessary, therefore, to concentrate during this period on the worst infested fields.

At about two weeks before harvest gather at least 500 straws selected from different parts of the field. Split each one open. Every straw that contains a sawfly grub will be partly filled with a sawdust like material. If 70% of the straws collected in a certain part of a field are infested, approximately 70% of the crop will be lying on the ground if it is not harvested till it is dead ripe. In another part of the field, or in another field, 2% only of the straws may contain this dust. Obviously, there is no urgent necessity to cut this area early, but every effort should be made to harvest as much as is possible of the first before damage shows up.

Implement manufacturers are now producing teeth to be fitted to combines that will gather many of the fallen straws. Their use greatly reduces losses.

References to Literature on Wheatstem Sawfly

Criddle, N., "The Western Wheatstem Sawfly," Entomological Branch, Ottawa. Pamphlet 6, 1924

Strickland, E. H., "Methods for Reducing Wheatstem Sawfly Damage," Department of Agriculture, Edmonton. 1930

WHEAT STEM MAGGOT (Meromyza americana).

Distribution. Uncommon in Alberta, but liable to be scatteringly present anywhere in the province.

Life history and habits. The maggots are the larvae of a very small green and black fly which lays its eggs on the blades in June. The young maggots, on hatching, work their way inside the leaf sheath to the top node. Here they feed on the flowering stem and entirely sever it from the plant. By the end of July the head dies and turns white.

Control. There is no practical control measure for wheat stem maggots in the small numbers in which they occur in Alberta.

Trap crops and poisoned bait for the flies have been employed elsewhere where the insect is more abundant.

WHEAT AND STEM MINERS (Hylemyia cerealis, etc.)

Distribution. As yet these insects have been recorded as attacking wheat only in the southern half of the province.

Life history and habits. The flies, which much resemble house flies, are active shortly after the grain is above ground in the spring. They lay their eggs on the young plants. Their maggots are very similar to root maggots of cabbages. They burrow into the plant and feed chiefly on the central shoot. This wilts, while the older leaves continue to grow though they may assume a bluish tint.

In a badly attacked field it may appear, during the latter part of May, that the crop is entirely ruined. At about the time that the owner decides to plough it in, it is probable that a marked improvement will be noticed. This is due to the fact that the maggots have matured and have left the plants in order to pupate in the soil.

Control There are few records of wheat fields in Alberta being badly infested with this insect When its presence is suspected a few plants should be pulled up and torn open in order to expose any maggots that may be present near their base Having thus determined the cause of the trouble, the farmer should be in no hurry to take any action. Provided there is sufficient rainfall, most of the attacked plants will recover, and their development will be found to have been retarded very little despite their unhealthy appearance earlier in the season.

Deep fall or spring ploughing reduces the numbers of flies that will emerge during the spring.

GRAIN THRIPS (Anaphothrips striatus).

Distribution. Entire province.

Life history and habits Thrips are minute, slender insects about 1/16" long. They are so small that they are rarely seen If a dandelion flower be tapped on the hand it is probable that a few of them, which are thus dislodged, will be seen running across the hand. They are quite strong fliers.

Grain thrips pass the winter in stubble, in grass along the headlands and among weeds. Early in the spring they lay minute eggs in small slits cut in the leaves of grasses. Small wingless thrips hatch from these and feed on the young growth of grass By about the end of June these thrips are full grown and have developed wings. The females leave the grass and many fly to grain Here, also, they lay eggs in small slits cut in the upper blades.

The young thrips that hatch from them enter the "boot" and feed on the developing grain flowers. They will not feed on any flowers that are already exposed at this time, but only on those that are still protected by the sheath.

Damage to grain. Oats suffer more than do other grain crops. "Blind" oats, i.e., oat flowers that turn prematurely white and which contain no seed, are produced by a variety of different causes. When they are scattered throughout the heads of oats their presence is not due to insect damage. Blind oats that are confined to the base of the head are, however, often caused by thrips.

In order to make certain whether thrips are present in sufficient numbers to have caused the trouble, gather a few of the upper blades from injured plants. Hold them to the light.

Small transparent areas, like pin-points, indicate places where thrips have laid their eggs. Tear open the upper leaf sheath to expose the flowering stem down to the top node. If thrips are abundant it is probable that a few dead specimens will be found within the sheath.

Control. Since grain heads that are fully exposed by the end of June are not attacked, only late seeded oats and barley are liable to suffer from thrips injury. Early seeding of rapidly maturing varieties will largely overcome the trouble in badly infested fields.

Fall ploughing or fall stubble burning, with the destruction of rank growth of grass along the headlands, will destroy many of the hibernating thrips. They are active so early in the spring that spring operations are of comparatively little value.

FALSE CHINCH BUGS (Nysius ericae).

Distribution. Entire province. Most prevalent where mustard grows to profusion.

Life history and habits. These bugs are only about 1/8" long, and they closely resemble Chinch bugs, for which they are sometimes mistaken. The true chinch bug does not occur in Alberta, and it has a white area over the greater part of the hinder end of the body. This is missing in the false chinch bug, which is almost uniformly greyish-brown.

Winter is passed by the full grown bugs which hide under dead vegetation. In the spring they resume activity and, with their hollow needle like mouths, they suck sap from practically all types of plants. They lay their eggs on the plants on which they are feeding. From these hatch small bugs that are similar in appearance to their parents, though they will remain wingless till they are full grown. There are several generations in a year.

Damage to grain. False chinch bugs increase rapidly in numbers in fields that have grown up to mustard and some other weeds. When such fields have been cleaned up and seeded in the spring, the bugs that have passed the winter successfully attack the grain seedlings and suck sap from their blades. Each feeding puncture turns red, and the portion of the leaf beyond it may become a sickly yellow. If mustard seedlings now appear in fairly large numbers, nearly all of the bugs will leave the wheat and feed on them. In any case, the damage is not severe, though the plants are set back

to a greater or less extent. Later in the season, when mustard is mature and is dying off, many bugs return to the grain and feed on the flowering stem and on the outside of the leaf-sheaths. They produce a blistered, rust-like effect by so doing.

Control. Keep summerfallow clean. There will then be no weeds on which the bugs can increase in numbers.

Plough in weedy stubble in the fall, or burn off early in the spring. Since the bugs are quite active at the usual time of spring ploughing this will not make a thorough job of burying them, though it is preferable to cultivation.

GRAIN APHIS (Macrosiphum granarium)

Distribution. Entire province. Frequently extremely numerous.

Life-history and habits. Occasionally the heads of all grain crops are found to be swarming with small wingless orange or green plant-lice or Aphids. Scattered among them will be a few individuals that are darker in colour, and which possess transparent wings.

It is not known how these plant-lice pass the winter in Alberta. It is possible that they are unable to do so here, and that infestations are the result of a few flying aphids that migrate into the province from farther south early in the summer.

Plant-lice can increase in numbers more rapidly than can any other insect. Generation follows generation rapidly throughout the summer. All remain wingless unless they have become so numerous on a single plant that they are seriously overcrowded. Whenever this occurs a few winged specimens appear. These fly to and infest new plants. They feed by sucking sap from the heads and from the stems of plants.

Damage to grain. However abundant the plant-lice may be, they do surprisingly little damage. We have seen a field of oats in which the lice were so numerous at harvest-time that the binder was literally gummed up with their crushed bodies. This field yielded 110 bushels per acre! A field of wheat, similarly infested, yielded 34 bushels of No. 1 grain.

The chief damage, therefore, is in rendering harvesting operations disagreeable.

Control. Nothing practical can be done to prevent infestations or to reduce the plant-lice present in grain. We have never known them to occur for two years in succession in the same district.

LEATHER JACKETS (Tipula Spp., etc.).

Distribution. Entire province. Abundant only in damp localities and in irrigated fields.

Life-history and habits. Leather jackets are the larvae of the extremely long legged flies known as Crane-flies, or "Daddy long legs." They somewhat resemble dull brown cutworms with no legs or heads.

Although they feed on the roots of grains and grasses, they are never present in sufficient numbers to cause appreciable damage to grain.

MARCH FLIES (Bibio albipennis).

Distribution. Entire province. Abundant only where much decaying vegetation is present, such as in comparatively new breaking or in heavily manured fields.

Life-history and habits. Occasionally, when seed-beds are being prepared in the spring, the ground is found to be swarming with dull brown grubs, about ¼" long, that, on close examination, are found to be covered with fleshy spurs somewhat resembling rose-thorns. They are full-grown at this season, and very soon will pupate beneath the surface of the soil. Later they mature into flies that somewhat resemble large, clumsy mosquitoes.

Since these grubs feed only on decaying vegetation, they are quite harmless to grain.

BEET WEBWORM (Loxostege sticticalis)

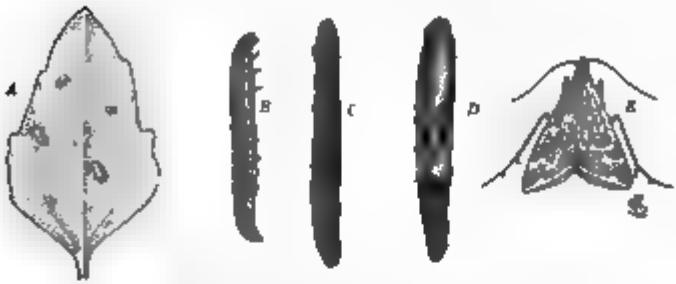


FIG. 11. Beet Webworm. A. Eggs, laid on under side of Lambsquarters leaf. B. Full-grown Beet Webworm (Green with black marks). C. Cocoon dug from the soil. D. Cocoon opened to show Pupa. E. Adult moth (Light yellowish brown). All figures natural size. (Original.)

Distribution. Entire province. Liable to be extremely abundant in every district.

Life history and habits. Beet webworms are the caterpillars of small light-coloured moths that are about ¾" long and of rather slender build. These moths occasionally fly in dense swarms along the side of roads in May and June and again in August. They lay nearly all of their eggs on lambsquarters. From these eggs hatch green and black caterpillars that feed on the weeds. When too many eggs have been laid on the same plants the caterpillars devour them completely, and then move across the ground in dense armies in search of more food. Once they have chosen their "line of march" nothing will deter them. They will climb up houses, over the roof and down the other side, if these happen to be in their way. At this time they feed on a great variety of different plants, but, generally speaking, *will not touch grain.* A somewhat rare exception to this occurs when a large army is passing through a field of wheat in which the heads are just exposed. Under these circumstances a few of the caterpillars will ascend the plants and eat some of the developing flowers from the wheat heads. Despite this unfortunate habit, webworms that pass through a field of wheat do far more good than harm. They destroy every weed that they encounter. When the caterpillars are full-grown, they enter the soil and there make a long earth-covered cocoon of white silk. In this they transform to the moths.

As a rule there are two generations of beet webworms in a year. Migrating swarms of caterpillars may be seen towards

the end of June and again in early September Under certain climatic conditions, however, the first generation only is completed The winter is passed in the cocoons, which may be turned up in large numbers when a field that was weedy during the previous summer is being cultivated in the spring.

Control. No control measures are necessary when these caterpillars are found in grain fields. They are doing far more good than harm.

Fields of beets, sunflowers or flax can be protected from invasion with furrows baited with lambsquarters (see page 26), or with cutworm bait (see page 25) When they are already present in such fields spraying with Paris green will give the best results.

DIAMOND BACKED MOTH (Plutella maculipennis).

Life-history and habits. Occasionally, at harvest time, heads of wheat are found to be carrying small lace-like cocoons through which can be seen a small caterpillar or chrysalis. The cocoons are about the same length as a grain of wheat These are quite harmless to the wheat. The green caterpillars of the diamond backed moth feed on mustard and a few other weeds. When they are full-grown many of them leave the plants on which they have fed and climb neighbouring stems of wheat, on the heads of which they spin their cocoons. They never feed on the wheat, and have done more good than harm by destroying a small amount of the weeds.